FEATURE

Higher Carbon Prices Could Spur Adoption of Methane Digesters

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- A market price for carbon emission reductions would allow livestock producers with methane digesters to earn additional revenue from trapping and burning methane from manure.
- Greater income from reducing methane emissions could substantially increase the number of livestock producers who would find it profitable to install methane digesters.
- Large-scale hog and dairy operations with lagoon manure management systems are likely to benefit most from a higher carbon price, which could have longrun structural implications for the livestock sector.

Methane digesters that collect and burn methane from manure can provide numerous benefits to livestock producers and the environment. Still, digesters have not been adopted widely, mainly because the costs of constructing and maintaining these systems have exceeded the benefits accruing to operators. Currently, there are 157 methane digesters operating in the U.S., of which 126 are on dairies and 24 are on hog operations.

Methane is a potent greenhouse gas (GHG), and burning 1 ton of methane is equivalent to eliminating about 24 tons of carbon dioxide. There are a number of policies that could encourage farmers to use a digester to reduce methane emissions, either by providing financial inducements for those who install a digester or by penalizing those who do not (see box, "Policy Options for Mitigating Methane Emissions From Manure Management").

A carbon offset market is one mechanism currently used for valuing methane emissions reductions. An offset market allows livestock producers who reduce methane emissions to sell these reductions, or "carbon offsets," to other greenhouse gas emitters who face emissions caps or who voluntarily wish to offset their own emissions. Currently, only a few U.S. livestock operators sell offsets in regional or voluntary carbon offset markets. This is partly because the carbon prices in these markets have been low. However, future efforts to reduce greenhouse gas emissions could result in substantially higher carbon prices.

If farmers could earn a higher price for their methane emissions reductions, then digesters could become profitable on many more operations. However, there is likely to be wide variation in the scale, location, and characteristics of the operations that would benefit. The main beneficiaries would be producers whose operations emit

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A covered anaerobic lagoon; methane is captured and piped to the combustion device.

substantial quantities of methane—particularly, dairy and hog operations with lagoon or pit manure storage facilities. Among these, larger scale operations will likely profit more from higher carbon prices because it is generally more cost effective to construct and operate larger digesters than smaller ones. Consequently, in the long run, valuing emissions reductions could encourage further concentration in the dairy and swine industries unless ways are found to promote the adoption of digesters on small-scale operations.

Digester Profitability and Adoption Depend on Farm Size, Location, Manure Management System, and Carbon Price

Methane digesters, also known as "anaerobic digesters," "biodigesters," or "biogas recovery systems," can be used to capture and burn methane from lagoon or pit-type manure storage facilities. With lagoons (earthen storage ponds), covers are installed to capture the methane. With pit systems (concrete or metal tanks located above or below ground), manure can be heated to encourage methane production. Digesters collect manure, optimize it for the production of methane by adjusting temperature and water content, capture the biogas, and burn it for heat or electricity generation. Burning methane reduces its global warming potential, which corresponds to a reduction in greenhouse gas emissions that could be marketed as a carbon offset.

Several factors influence the profitability of methane digesters and consequently determine which types of producers are likely to adopt the technology. These factors include an operation's manure management method, startup and ongoing costs of a digester, buying and selling price of electricity, onfarm electricity expenditures, and carbon offset price. Many of these factors vary with farm size and location.

Policy Options for Mitigating Methane Emissions From Manure Management

There are several possible policy approaches to mitigating methane emissions from manure management. The effectiveness and the distributional implications of these policies are likely to be very different. One approach is to regulate emissions levels on individual operations. This would give producers an incentive to adopt technologies, such as digesters, to comply with the standards. Another regulatory approach is to require specific emissions reduction technologies, such as lagoon covers and methane flares. Digester adoption could be encouraged with cost subsidies or other incentives, such as grants, cost shares, incentive payments, tax credits, or exemptions. Many existing incentive programs are designed to promote renewable energy, in addition to lowering greenhouse gas (GHG) emissions.

Policy approaches that use a price-based mechanism include taxes on GHG emissions or on the "carbon content" of commodities, such as meat or milk (the tax rate would depend on the quantity of GHGs emitted during production). Another approach is for individuals or firms who wish to "offset" their own emissions to pay farmers for reducing methane emissions. Such marketable emissions reductions or offsets are measured in tons of carbon dioxide equivalent emissions (reductions in other greenhouse gases such as methane are converted to an equivalent quantity of carbon dioxide based on that gas's global warming potential). Carbon offsets can be exchanged in markets established to satisfy regulatory compliance or in voluntary markets.

Compliance markets develop when regulations limit the amount of GHGs firms can emit, but permit regulated firms to trade emissions allowances. Under such a system, known as cap-and-trade, regulated firms (such as power plants) must obtain permits to emit GHGs. To meet their emissions targets, regulated firms can reduce their own emissions or purchase allowances from other "capped" firms. Alternatively, when allowed, regulated firms can pay nonregulated emitters, which might include livestock operations, to reduce emissions.

Current examples of compliance markets include the Kyoto Protocol and the European Union's Emissions Trading Scheme. While the United States does not have a national compliance market at present, the U.S. Congress has considered several bills in recent years that would have established a national cap-and-trade system. Additionally, 10 Eastern States recently implemented the Regional Greenhouse Gas Initiative (RGGI), the first mandatory domestic market-based effort to reduce GHG emissions. Voluntary offset markets allow companies and individuals to purchase carbon offsets. For example, individuals might seek to offset their travel-related emissions or firms might seek to compensate for emissions related to their products. In the U.S., the Chicago Climate Exchange (CCX) is a voluntary, but legally binding, carbon trading regime.

In the major international compliance markets, carbon prices ranged between $15 and $30 per ton in the past decade. U.S. offset prices have been much lower. The average price for carbon allowances in the RGGI ranged between $1 and $3 per ton since its inception in 2008 through 2010. The CCX carbon price ranged between $1 and $7 per ton between 2004 and 2008 but has traded under $1 per ton since 2009.

A plug flow pit-based methane digester.

Only operations that generate a significant quantity of methane are viable candidates for biogas recovery systems. When manure is kept in oxygen-free (anaerobic) conditions that exist in lagoons, ponds, tanks, or pits, it decomposes to produce a biogas containing about 60 percent methane. When manure is in oxygen-rich environments, such as when it is deposited on fields, it generally produces little methane. Many dairy and swine operations employ anaerobic manure management facilities. Dairy cattle and swine are each responsible for 43 percent of U.S. methane emissions from livestock manure. Other livestock sectors predominantly using aerobic manure management methods, including beef cattle, sheep, poultry, and horses, are collectively the source of only 13 percent of emissions.

Anaerobic manure management methods are generally more common on large-scale operations. For example, only 38 percent of dairy operations with fewer than 250 head use anaerobic manure management systems, compared with 56-73 percent of larger operations. Consequently, larger operations produce a disproportionate share of methane emissions; dairies with more than 2,500 head accounted for 19.7 percent of total emissions in 2005, though they only produced 13 percent of dairy output.

There is substantial variation across regions in manure management methods and, consequently, methane emissions. Dairies in the West and South are much more likely to have lagoon systems than those in the Midwest and Northeast. Dairies in the West produce 43 percent of all emissions from the dairy sector, reflecting that region's large share of output and the prevalence of lagoon systems.

Factors determining digester profitability vary by dairy size and region, 2005

Category	Number of farms in category	Percent of dairy output	Percent with lagoon or pit manure system	Percent with lagoon (could also have pit)	Percent of total methane emissions	Electricity use per head (kWh)	Electricity price ($/kWh)
All farms	52,237	100	42	11	100	1,048	0.069
Number of head							
>2,500	248	13.0	55.6	48.0	19.7	494	0.078
1,000-2,499	917	18.3	63.5	38.9	20.9	723	0.081
500-999	1,615	14.1	71.3	41.5	18.4	743	0.079
250-499	3,040	13.5	72.8	40.0	16.0	775	0.068
<250	46,417	41.1	38.0	6.9	25.0	1,085	0.068
Region							
West	6,095	33.3	56.5	38.1	43.1	893	0.058
Midwest	28,438	36.4	40.2	5.8	26.0	1,102	0.064
South	4,034	9.2	53.0	27.1	15.6	791	0.065
Northeast	13,670	21.1	34.3	3.8	15.3	1,080	0.085

Note: All dollar values are in 2009 real (adjusted for inflation) terms.

Source: USDA, Economic Research Service estimates using data from USDA's 2005 Agricultural Resource Management Survey, Dairy Cost of Production Survey.

Digesters revenues flow disproportionately to large dairies and dairies in the West, 2005[1]

Category	Number of farms that would earn positive profits	Revenues from offset sales	Value of generated electricity	Net revenues from digester	Average net revenues from digester per farm	Average net revenues from digester per head
		Million dollars			Dollars	
All farms	1,848	1,392	1,050	908	491,478	304
Number of head						
>2,500	138	449	271	419	3,039,112	654
1,000-2,499	521	457	460	323	620,599	410
500-999	732	352	249	147	201,158	286
250-499	458	134	71	19	42,091	108
<250	0	0	0	0	0	0
Region						
West	972	780	559	542	558,212	332
Midwest	281	162	164	72	257,720	165
South	354	243	151	152	429,384	334
Northeast	242	206	177	142	585,716	312

[1]Carbon price = $13 per ton.

Notes: Revenues correspond to the net present value of a project with a 15-year lifespan discounted at a rate of 5 percent. All dollar values are in 2009 real (adjusted for inflation) terms.

Source: USDA, Economic Research Service estimates using data from USDA's 2005 Agricultural Resource Management Survey, Dairy Cost of Production Survey.

The costs of building, maintaining, and repairing manure storage facilities and electricity generators generally decline on a per head basis with the size of the operation, which makes digesters more cost effective for larger scale operations. In addition, there can be substantial transactions costs associated with selling electricity or certifying and marketing carbon offsets. Larger operations can spread these costs over a larger revenue base.

Digester profitability depends on the value of the electricity generated, which varies by farm size (electricity use per head declines, on average, as herd size increases) and by region (electricity is most expensive in the Northeast and least expensive in the West). In most States, operations that generate more electricity than they use can sell their surplus electricity to the grid. However, the selling price of electricity varies widely and depends, in part, on whether local utilities are required to purchase renewable energy. Renewable energy mandates can substantially raise the selling price for digester-generated electricity and make adopting a digester more profitable. Whether an operation has surplus electricity depends on its generating capacity relative to its demand. On average, dairies in the West and South use substantially less electricity per head than farms in the Midwest or Northeast, and so have more electricity to sell.

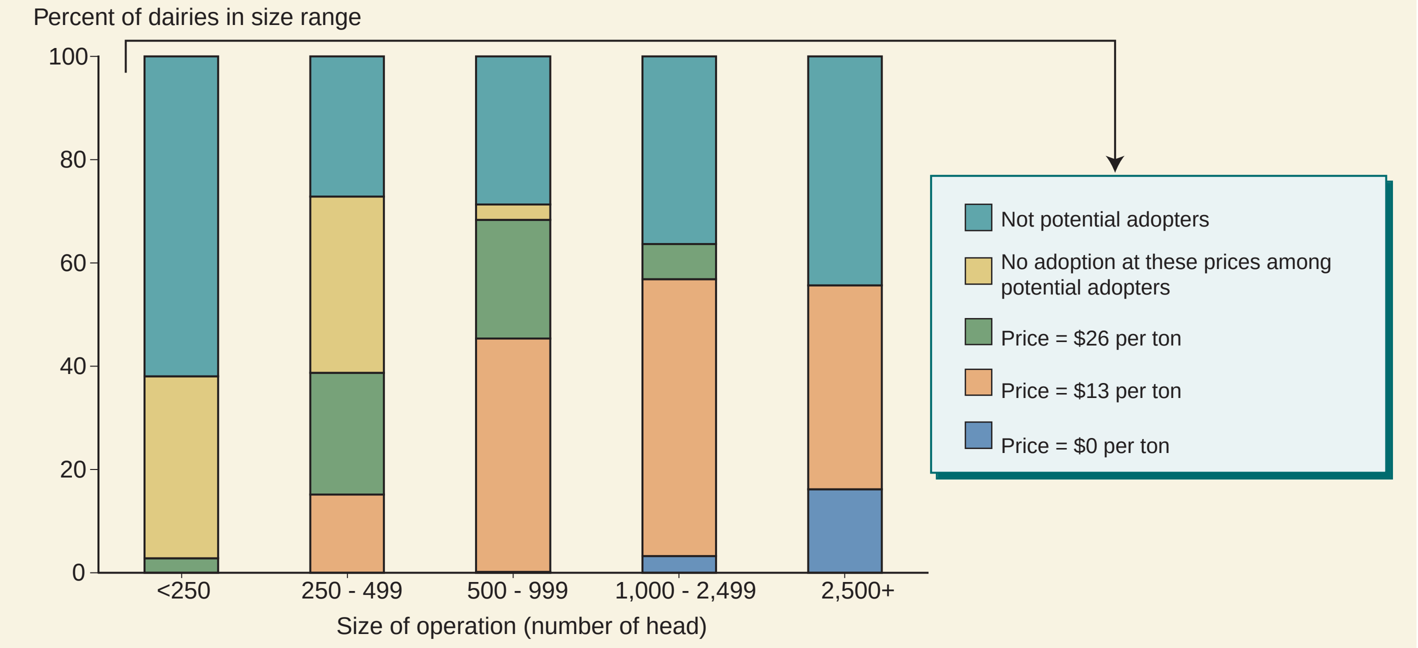
Revenues From Increasing Carbon Prices Mainly Would Accrue to Large Dairies in the West

ERS researchers used data from USDA's Agricultural Resource Management Survey (ARMS) and a model of digester profitability to estimate the number, size, and location of dairy and hog operations that might adopt a methane digester at different carbon offset prices. ARMS is conducted by ERS and USDA's National Agricultural Statistics Service (NASS). The researchers also estimated the distribution of the discounted stream of revenues over the life of the digester from emission reductions, the value of electricity generated, and total profits.

Research results indicate that even with moderate carbon offset prices, offset sales could substantially increase revenues for farms with digesters. At $13 per ton for carbon, the revenues from offset sales for dairies would exceed the value of digester-generated electricity by almost 30 percent. The revenues from digesters would accrue mainly to large-scale operations. Over 15 years, digesters would be worth $419 million to dairy operations with at least 2,500 head, or about 46 percent of the total value of dairy digesters.

Mixing tanks at a "complete mix" pit-based digester.

Higher carbon offset prices would increase the percent of dairies that could earn positive net revenues from a digester



Notes: Percentages at higher prices are additive to those for lower prices; for example, at a price of $13 per ton, an additional 54 percent of operations of size 1,000-2,499 are predicted to adopt, for a total of 57 percent of operations of this size. At a carbon price of $13 per ton, no operation smaller than 250 head is predicted to adopt. At a carbon price of $0 per ton, no operations with fewer than 500 head and 0.1 percent of operations with 500-999 head are predicted to adopt.

Source: USDA, Economic Research Service estimates using data from USDA's 2005 Agricultural Resource Management Survey, Dairy Cost of Production Survey.

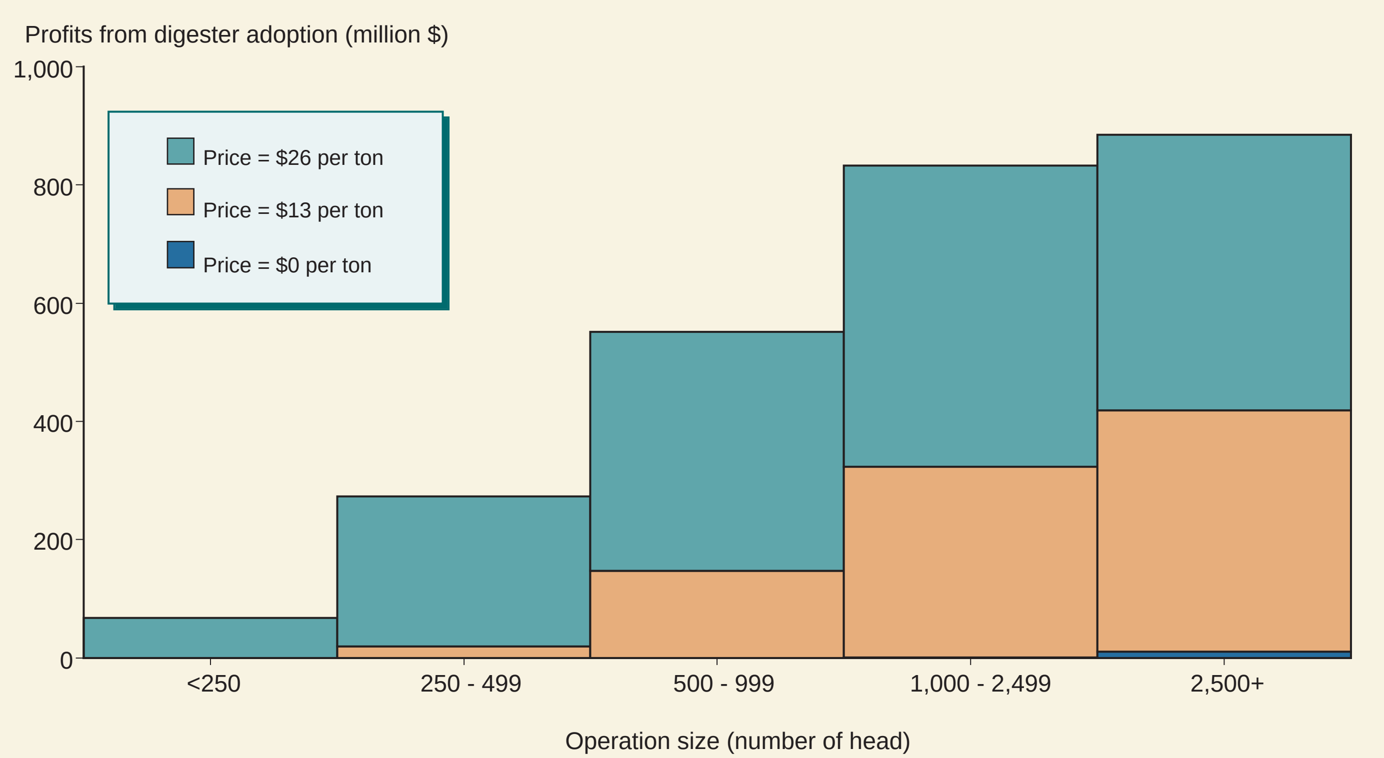
Profits per farm and per head increase with farm size, which could give larger operations a substantial competitive advantage. At $13 per ton, it would not be profitable for operations with fewer than 250 head to adopt a digester. Regionally, dairies in the West would receive almost 60 percent of total digester profits, reflecting the prevalence of large-scale dairies in the region.

As carbon offset prices increase, more small-scale operations would find it profitable to adopt a digester. When there is no offset market (a price of zero), only operations with at least 1,000 head earn profits from operating a digester. However, if the offset price increases to $13 per ton, 15 percent of farms with 250-499 head and 45 percent of farms with 500-999 head would earn profits. If the price increases to $26 per ton, 3 percent of farms with fewer than 250 head and 39 percent of farms with 250-499 head would find it profitable to adopt a digester.

The substantial share of dairy operations without anaerobic manure management systems likely could not sell carbon offsets even if they were to install digesters. Farms that replace an aerobic manure management system (such as depositing manure on fields) with a pit or lagoon system would actually increase methane emissions. Even if the same farms then added digesters and reduced emissions to prior levels, these reductions likely would not qualify as carbon offsets. To be eligible as carbon offsets, emissions reductions usually must be "additional" to "business as usual"; as the level of emissions with aerobic manure management would be about the same as with anaerobic manure management plus a digester, there would be no additional reductions in methane emissions.

Higher offset prices would increase the profits that the livestock sector could earn from digesters. Over 15 years, the value of digesters to dairies is about $11 million with no offset market, about $908 million with a carbon price of $13 per ton, and $2.6 billion with a price of $26 per ton. Digester profits accrue mostly to large farms regardless of the carbon price. However, higher prices increase the

Net revenues from digesters accrue mainly to large operations and increase with carbon price



Source: USDA, Economic Research Service estimates using data from USDA's 2005 Agricultural Resource Management Survey, Dairy Cost of Production Survey.

An engine generator that combusts biogas for use on farm. AgSTAR

number of smaller farms that could benefit from an offset program, which causes the distribution of benefits to become somewhat less skewed toward the largest operations. Dairies with at least 2,500 head earn 94 percent of digester profits with no offset market, compared with 48 percent at a price of $13 and 37 percent at a price of $26.

Policies and Facility Sharing Could Enable Smaller Livestock Operations To Build Profitable Digesters

Depending on the price of carbon, the additional income from offset sales could substantially increase the number of livestock producers who would find it profitable to install methane digesters. In recent decades, the scale of production in the dairy and hog sectors has increased dramatically. Dairies with at least 1,000 head now produce almost a third of output, despite accounting for only about 2 percent of all operations. The additional profits that large farms could earn from digesters could enhance existing economies of scale in dairy and hog production and promote further consolidation of production over time.

One way for smaller scale livestock operations to achieve a more efficient scale is by supplementing manure with food waste from nearby crop or meat processing facilities, breweries, bakeries, and restaurants. When mixed with manure, food waste can provide an efficient feedstock for biogas production, and as an added incentive, livestock operators could collect waste disposal fees from the food facilities. However, the availability and suitability of food waste for use in methane digesters may restrict the feasibility of such mixtures to certain locations.

A centralized digester is another way that smaller scale operations could take advantage of a more efficient digester size. With several nearby farms using a single large digester, participating operations could share construction and maintenance costs; increase their leverage to negotiate electricity sales; improve access to financing, tax credits, or grants; and allow a manager to develop specialized skills in digester maintenance and operations. The main disadvantage to centralized digesters is the additional cost of transporting manure to and from the central facility.

If carbon offset prices are sufficiently high, a lower cost biogas system that flares methane rather than uses it to generate electricity may become profitable. This approach removes electricity generation from the biogas system, which eliminates the costs of the generator, electrical connections, and much of the maintenance. The lower cost biogas system might be economically viable for smaller scale operations that would find it difficult to finance or maintain an electricity generator. This option has the greatest potential for operations with lagoons, since lagoon covers can be installed relatively inexpensively, and offers other benefits to producers, such as reducing odor and increasing lagoon storage capacity by excluding rainwater.

Policies that raise returns to or lower costs of digesters can provide incentives for smaller scale operations to adopt the technology. Policies could include grants, such as USDA's Rural Energy for America Program Grants, and incentive payments, such as the U.S. Department of Energy's Renewable Energy Production Incentive. Other policy options include tax credits, such as the Renewable Electricity Production Tax Credit, accelerated depreciation (allowing construction costs to be written off faster for tax purposes), property and sales tax exemptions (usually at the State level), and other regulations, such as renewable energy mandates that raise the effective price of electricity sold to the grid. Many of these policies can be targeted toward smaller scale operations. W

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